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Airline capacity discipline in the U.S. domestic market

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ABSTRACT

Using data from 1995 to 2016, this study examines airline capacity growth in the U.S. domestic market, and its impact on revenue. The results show that, after controlling for the strength of the economy and the price of fuel: (1) decreases in total domestic airline capacity are strongly correlated with increases in average domestic revenue per available seat mile (RASM); and (2) decreases in total domestic airline capacity are strongly correlated with increases in total domestic revenue. The results also show that using the real GDP growth rate as the focal point for capacity growth may help airlines maintain or slightly increase RASM over time.

The data show that the average year-over-year domestic capacity increase during 2011–2015 was lower than in the past. Also, while individual airlines continue to add capacity at different rates, the variation between airlines is less than before industry consolidation.

1. Introduction

Between 2001 and 2010, U.S. airlines had a collective net loss of over $58 billion. Summarizing a widely-held view of the industry, famed investor Warren Buffett observed that "if a farsighted capitalist had been present at Kitty Hawk, he would have done his successors a huge favor by shooting Orville down" (Buffett, 2008). He complained about the "kamikaze pricing tactics of certain carriers," and concluded that "[i]t's impossible to be a lot smarter than your dumbest competitor" (Buffett, 2007). From 2011 to 2016, however, the situation changed dramatically as U.S. airlines reported a collective net profit of over $56 billion.[1] In 2016, Buffett's firm concluded that the industry appeared to have solved its long-standing overcapacity problem, and made large investments in each of the four major U.S. airlines (Derousseau, 2017).

What changed over this period and why? The most obvious change since 2000 has been the consolidation of the U.S. airline industry from seven major airlines into four much larger airlines[2] that collectively have about 80 percent of domestic capacity, as measured by available seat miles.[3] Over a five-year period beginning in 2009, mergers took place between Delta and Northwest; United and Continental; Southwest and Airtran; and American and US Airways.

The conventional wisdom espoused by airline industry analysists and executives is that limited capacity growth or "capacity discipline" is the key to improved airline profitability and that "capacity should not grow more than GDP" (Reed, 2015). Despite the importance of this subject, no prior published study tests the relationship between capacity discipline and U.S. airline financial performance.

Using data from 1995 to 2016, this study examines capacity growth in the U.S. domestic market, and its impact on RASM[4] and revenue. The results show that, after controlling for the strength of the economy and the price of fuel: (1) decreases in total domestic airline capacity are strongly correlated with increases in average domestic RASM; and (2) decreases in total domestic airline capacity are strongly correlated with increases in total domestic revenue. In addition, using the GDP growth rate as the focal point for airline capacity growth may help airlines maintain or slightly increase RASM over time. Although it is not surprising that greater domestic capacity is correlated with lower airfares, the strength of the relationship between capacity changes and changes in average RASM and airfare, and total domestic revenue is surprisingly strong, especially since 2005.

The data show that the year-over-year domestic capacity increase and variance for the five-year period 2011–2015, were lower than in the past. Also, while individual airlines continue to add capacity at different rates, the variation between airlines is less than before industry consolidation.

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[1] Source: SEC reports 2016 and MIT Airline Data Project.

[2] In 2000: United, American, Delta, Northwest, Continental, US Airways, and Southwest, plus several much smaller airlines. In 2016: American, Delta, United, and Southwest, plus several much smaller airlines. Airline mergers since 2000 and capacity added by merger are shown in Appendix A1. See Borenstein (2011) for discussion of why airlines have been unprofitable; see Morrison (1996) for long term effects of airline mergers.

[3] In an industry where the product is instantly perishable, capacity is synonymous with supply.

[4] Capacity is measured by Available Seat Miles (ASMs); unit revenue is measured by Revenue per Available Seat Mile (RASM).

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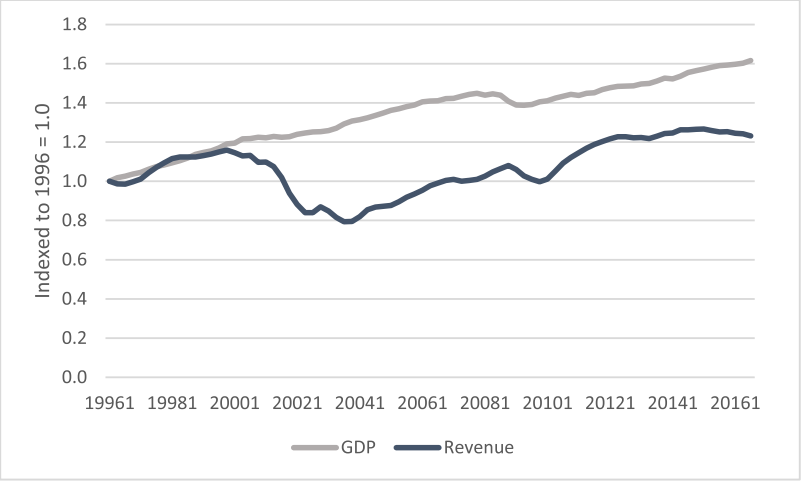


Fig. 1. Real domestic revenue and chained GDP, Indexed to 1996 = 1.0. Source: Diio compilation from US DOT Form 41, and Bureau of Economic Analysis.

Notes: 19961 denotes 1st quarter 1996. Domestic capacity and revenue are rolling last 4-quarters.

The reason for focusing on the domestic airline market, as opposed to the combined domestic and international U.S. airline market is that only U.S. airlines are permitted to provide domestic service and only four U.S. airlines provide about 80 percent of domestic capacity. Conversely, many foreign and U.S. airlines prove international air service to and from the U.S., which makes it much less likely that airlines will align their international capacity to maximize collective profitability. In addition, data on international airfares is less reliable and subject to federal nondisclosure rules.

The study raises fundamental questions for further research. Why has the consolidated industry been more successful at limiting capacity growth? Is limited capacity growth a natural consequence of consolidation and, if so, is it likely to be a permanent feature of the U.S. airline industry?[5] What factors other than industry concentration may be important in fostering "capacity discipline"?

2. Background

The U.S. domestic air travel market is mature. As shown in Fig. 1, total domestic airline revenue grew by only 24 percent in real terms over the 20-year period from 1996 to 2016, compared with 60 percent real GDP growth. The comparison is important because of the claimed relationship between GDP growth and industry revenue growth, which will be discussed later. Industry analysts commonly assume that industry revenue will grow at about the rate of GDP growth, but this has been true only for limited periods.[6]

As shown in Fig. 2, during portions of the past 20 years, domestic airfare and passengers have moved in roughly opposite directions, as to a lesser extent have capacity (ASMs) and unit revenue (RASM). Throughout the 20-year period, improved revenue management and scheduling practices enabled the airlines to continually increase load factors,[7] which in turn allowed them to generate higher RASM and to expand capacity by less than the increase in passengers. Fig. 2 shows the changes in airfare, passengers, RASM and ASMs, as well as the seasonal nature of the business.[8]

Airline analysts and industry executives have long claimed that airline profitability and pricing power are dependent on industry-wide "capacity discipline" and that healthy airline revenue growth requires that airline capacity increases be limited to approximately the same rate as GDP growth. This study examines these claims. See examples below.

Credit Suisse (Yates, 2014):

> Five major mergers since 2005 have consolidated the domestic airline industry to 4 carriers that control more than 80% of capacity. This oligopolistic structure and *consistent capacity discipline* is driving sustainable pricing power.

The United States Government Accountability Office (2014, p.32):

> [U]nlike prior recoveries when airline capacity growth undermined the ability to charge profitable fares, airlines since 2009 have *restrained capacity growth* even though demand for air travel has risen with the economic recovery.

Maxon (2014):

> Regarding growth "'in line or below' the rate of the gross domestic product," "we're not sure who invented this, but many now believe it represents a threshold of what's acceptable."

Reed (2015):

> "A frequently cited rule of thumb is that capacity should not grow more than GDP."

Rich (2015):

> "Wall Street prefers that capacity grow in line with GDP."

CAPA (2017):

> United "has been a strict adherent to keeping capacity growth in line with GDP."

Stalnaker et al. (2017, p. 10)

> "We continue to postulate that a positive revenue environment depends on capacity discipline at or below GDP growth."

Under Cournot conditions, when firms limit supply, the price adjusts

[5] For example, American Airlines' CEO was quoted in September 2017 as saying that the airline industry has changed so radically that his company will never lose money again: "We have an industry that's going to be profitable in good and bad times" (Koenig, 2017).

[6] See Stalnaker et al. (2016, p.19), "The theory is that domestic airline revenue is largely a function of GDP and, therefore, unit revenue (yield) will be diluted to the extent that capacity increases at a more rapid rate than GDP".

[7] From 1995 to 2015, the average domestic load factor increased from 66 to 86 percent. Source: analysis of data from MIT Airline Data Project.

[8] Because of the seasonal nature of domestic capacity, a seasonal fixed effect was included in the initial regression analysis, but proved to be unnecessary as the results were virtually identical to a simple analysis of year-over-year changes on a quarterly basis.

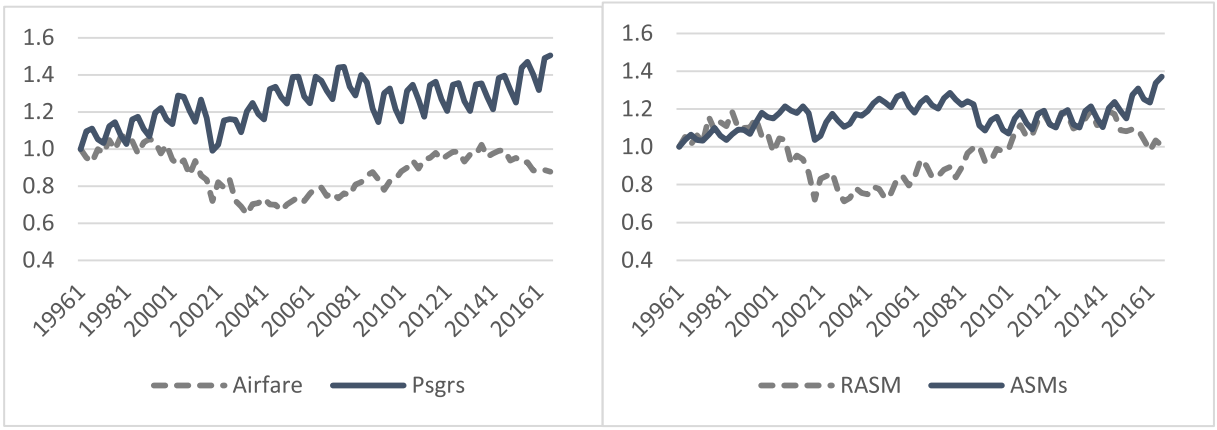


Fig. 2. Average real airfare and passengers, and average real RASM and ASMS, indexed to 1996 = 1.0.
Source: Diio compilation from US DOT Form 41.

to clear the market (Kaplow and Shapiro, 2007, p. 8). The typical demand function is inverted so that price is a function of quantity supplied, instead of quantity supplied being a function of price. Prior studies have found that airline conduct is generally "consistent with the Cournot solution" (Fischer and Kamerschen, 2013, p. 91) or "reasonably close to Cournot behavior," (Brander and Zhang, 1990, p. 580), although these studies tend to focus on competition on individual routes served by multiple airlines or duopoly routes, as opposed to industry-wide conduct.

The study results show that when domestic airline industry capacity decreases, holding underlying economic factors constant, average RASM increases, average airfare increases, and total domestic revenue increases.[9] Airlines collectively have an incentive to limit capacity because doing so increases RASM and industry revenue, and they have done so with increasing success since 2009. Airline executives also use sophisticated price discrimination tools to maximize revenue, but they recognize that these tools operate within the context of industry capacity, which is the dominant factor in determining price.

Further research is needed to fully explain why individual airline executives have been more willing to limit capacity growth as the number of large airlines has decreased from seven to four. One explanation relies on a version of the prisoner's dilemma. A single airline benefits by aggressively increasing capacity if competitors don't match; but if they do, the expanding carrier loses the benefits of the expansion. The long-term cooperative solution is for all airlines to limit capacity growth. Under this theory, U.S. airlines have been able to reach a cooperative solution in the years since consolidation because of the smaller number of airlines that must cooperate.[10] In that case, how important is the actual number of airlines in achieving a cooperative solution? How important are other factors, such as the market share of each airline relative to others, the similarity of experience and industry background of senior executives, or the extent of common ownership by major investors? Does the increasing similarity of services – the commoditization of air travel – play a role in the convergence of capacity growth rates? Note that the concept of "cooperative solution" in this context need not imply explicit agreement among airlines, but simply that individual airline decisions are based on assumptions about how other airlines are likely to react.

The study focuses on revenue, as opposed to profitability, because airline profitability has been highly volatile and difficult to measure with consistency, as airlines have filed for bankruptcy, taken special charges, and relied on tax loss provisions. Increased airline revenue associated with lower capacity should mean increased profitability since lower capacity reduces the variable cost portion of the airline cost structure. The study also focuses on RASM, the most important unit revenue measure, because it incorporates the effects of changes in both airfare and load factor.

Table 1
Regression results – changes in Domestic RASM regressed against changes in capacity.

	(1)	(2)	(3)	(4)	(5)
	1996-1 to 2016-3	1996-1 to 2016-3 w/ controls	1996-1 to 2016-3 Ex 2001-3 to 2003-2	2005-1 to 2016-3	2009-1 to 2016-3
Capacity	−0.104 (0.315)	−0.755 (0.220)***	−1.533 (0.197)***	−1.403 (0.193)***	−1.280 (0.184)***
Imports		0.609 (0.144)***	0.669 (0.075)***	0.535 (0.090)***	0.577 (0.104)***
Fuel		−0.054 (0.042)	−0.076 (0.029)**	−0.002 (0.030)	−0.030 (0.036)
Constant	0.001	−0.009	0.015	0.023	0.020
F	0.11	10.84***	52.99***	78.96***	65.75***
R^2	0.003	0.240	0.538	0.839	0.869
Observations	83	83	75	47	31

Standard errors in parenthesis (robust to heteroscedasticity).
Statistical significance at 1% (***), 5% (**), 10% (*).

3. Methodology and data

The study uses OLS regression to conduct several tests regarding the relationship between domestic airline capacity and domestic RASM and revenue.

The basic regression equations are:

$$\Delta \text{ Domestic RASM} = \alpha + \beta_1 \Delta \text{ Domestic Capacity} + \beta_2 \Delta \text{ Imports} + \beta_3 \Delta \text{ Fuel Price} + \varepsilon$$

$$\Delta \text{ Domestic Revenue} = \alpha + \beta_1 \Delta \text{ Domestic Capacity} + \beta_2 \Delta \text{ Imports} + \beta_3 \Delta \text{ Fuel Price} + \varepsilon$$

$$\Delta \text{ Individual Airline Domestic Revenue} = \alpha + \beta_1 \Delta \text{ Individual Airline}$$

[9] The number of passengers decreases, but the decrease is more than offset by the increase in revenue per passenger. See Smyth and Pearce (2008) for review of airline demand and elasticities. For the domestic market as a whole, the price elasticity of demand is inelastic, although individual routes may have high price elasticity.

[10] See Axelrod (1984) for discussion of conditions under which cooperation can emerge and persist in infinitely repeated prisoner's dilemma games.

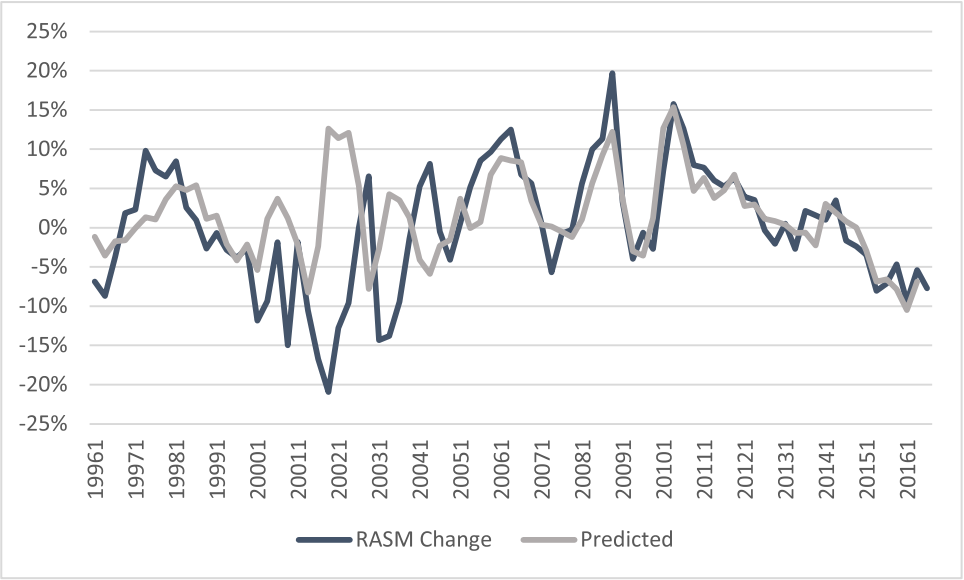


Fig. 3. Predicted domestic RASM change versus actual.

Domestic Capacity + β_2 Δ Other Domestic Capacity + β_3 Δ Imports + β_4 Δ Fuel Price + ε

Changes are measured in real dollar terms. Explanations for the selection of variables and time periods are provided below.

Measures of underlying demand for domestic air service – Based on prior work that tested seven factors[11] using a stepwise filtering process, changes in total imports are most predictive of domestic revenue changes. Our finding is consistent with Greene (2009, p. 3), who found that changes in the civilian unemployment rate and the level of imports were the factors most strongly correlated with changes in domestic airline revenue, and that these were coincident indicators. Although the causal relationship between imports and the underlying level of demand seems less direct than that for unemployment, changing levels of imports do reflect changes in the strength of the domestic economy. When both imports and unemployment are included in the regression equations, the unemployment coefficient has minimal impact on the main regression coefficient and is not statistically significant. Therefore, the study relies on the change in imports as the variable for the change in economic demand.

Fuel – The major components of the airline cost structure do not vary much from year to year, except for fuel. Because fuel costs have varied so widely and fuel has at times been the largest component of the airline cost structure, sometimes more than labor costs, the year-over-year percentage change in the quarterly domestic fuel price is included as a variable. As a proportion of airline operating expense, domestic fuel cost peaked at 36 percent in 2008, versus a minimum of 12 percent in 2002.[12]

Data – This study relies on data available on a quarterly basis from 1st quarter 1995 through 3rd quarter 2016 for domestic revenue, passengers, capacity, fuel prices, and economic growth factors.[13] Given significant changes in the airline industry over the years since full deregulation in 1980, there is little reason to rely on pre-1995 data, and in some cases, the data is not readily available.[14] Domestic passenger revenue was increased to include estimates for "change fees" and "baggage charges" not included in the base revenue recorded by DOT. Prior to 2000, these charges added less than one percent to the base fare, but since 2009, they have added approximately 6% to the base fare.[15] Data sources are listed in Appendix A2.

Treatment of 9/11 – The impact of 9/11 on airline demand was severe and outside of the ordinary range of economic factors. In the short term, some people were afraid to fly while others avoided flying as the new government-run security regime was established because of what has been called, the "hassle factor." Getting through the security line took too long and was too intrusive. Airlines reduced capacity in response to the immediate drop in demand, but could not do so quickly enough. These factors receded over time as travelers resumed making air travel decisions based on conventional economic factors. Because of these factors, the baseline results exclude data from 3rd quarter 2001 through 2nd quarter 2003, although this period is included in one of the regression alternatives.

4. Changes in industry capacity determine changes in RASM

Five scenarios were modeled, as shown in Table 1, to estimate the relationship between capacity changes and the change in real domestic RASM. Before controls are included, the relationship between changes in domestic capacity and changes in real domestic RASM is weak and statistically insignificant. However, once controls for underlying demand and fuel price are imposed, changes in domestic capacity predict changes in RASM. Specific findings are as follows.

Scenario 1 - Simple regression, without controls, of year-over-year percentage change in RASM over the percentage change in domestic capacity, for the period 1st quarter 1996 through 3rd quarter 2016. The simple regression in Table 1 Scenario 1 of the change in domestic capacity over the change in domestic RASM for the period 1996–2016 reveals a negative correlation between greater capacity and lower RASM, but it is weak and statistically insignificant.

[11] The factors tested on a set of annual airfare and capacity data were the year-over-year change in: (1) civilian unemployment rate, (2) total civilian employment, (3) exports, (4) imports, (5) personal income, (6) household income, and (7) GDP.

[12] Source: MIT Airline Data Project compilation from US DOT Form 41 via BTS, Schedule B6 & P5.

[13] Since the analysis is based on year-over-year changes, the first quarter included in the 20-year span is 1st quarter 1996.

[14] John Ackerman's offer to supply airline data for the study, and Naveen Bandla's

(*footnote continued*)
work in compiling that data are gratefully acknowledged. The largest commercial airline data provider does not have data on domestic airline revenue prior to 2000, so obtaining that data for the period 1996–1999 required processing several million rows of raw DOT data per quarter.

[15] Source: Airlines for America data and statistics, Annual Round-Trip Fares and Fees: Domestic, http://airlines.org/data/annual-round-trip-fares-and-fees-domestic/.

Scenario 2 – Multiple regression, with demand and fuel cost controls added, of annual change in domestic RASM over change in domestic capacity for the period 1st quarter 1996 through 3rd quarter 2016. With controls added, the strong correlation between domestic capacity changes and RASM changes becomes clear and is statistically significant at the 1 percent level. A one percent decrease in ASMs compared with the same quarter the prior year is associated with a 0.76 percent increase in domestic RASM. A stronger economy, as measured by the percentage increase in total imports, also results in higher RASM – a one percent increase in imports is associated with a 0.61 percent increase in domestic RASM.

Increasing the price of fuel has only a small and statistically insignificant impact on RASM, except in Scenario 3. This is surprising, but explained by the strong correlation (0.72), between imports and the price of fuel. When the economy strengthens, the price of fuel increases, as does the level of imports, and the impact on RASM works more directly through the economic demand channel (i.e., through imports) than the fuel price channel. The impact of changing fuel prices becomes evident if GDP is substituted for imports, as in Section 9 Table 4, where increasing fuel prices are associated with higher overall revenue. As noted, however, the overall fit of the regression is weaker when GDP is used instead of imports.

Scenario 3 –Excludes 3rd quarter 2001 through 2nd quarter 2003 to avoid the distortion caused by 9/11, and includes controls (imports and fuel) – this is referred to as the base scenario. In this scenario, a one percent decrease in ASMs compared with the same quarter the prior year is associated with a 1.53 percent increase in domestic RASM, and the result is significant at the 1 percent level. As in Scenario 2, a stronger economy, as measured by the percentage increase in total imports, also results in higher domestic RASM – a one percent increase in imports is associated with a 0.67 percent increase in RASM.

Scenarios 4 and 5 test the effects of capacity changes on RASM during and after periods when the most substantial mergers occurred. In 2005, US Airways and America West merged, arguably the first major merger in the series of mergers leading to the current domestic industry with four major airlines. Scenario 4 is for the period 2005+. In 2009, a final series of mergers between large U.S. airlines began with the merger of Delta and Northwest, followed by United and Continental in 2010, Southwest and AirTran in 2011, and American and US Airways in 2013. Scenario 5 is for the period 2009+. Data is available for only a few years for the "fully consolidated" domestic industry. Nevertheless, the 1996–2016 data clearly show a strengthening of the correlation between capacity and each of RASM, airfare, and industry revenue since 2005.

Scenario 4 –Covers the period beginning 1st quarter 2005, and includes controls (imports and fuel), to test whether different effects are observed more recently. The results are similar to Scenario 3, the base scenario. In this scenario, a decrease in domestic capacity of one percent is associated with an increase in average RASM of 1.4 percent, and the result is significant at the 1 percent level. However, the adjusted R^2 in this scenario of 0.839 is much higher than in the previous scenarios, suggesting that capacity and RASM are more tightly correlated as we move towards a more consolidated domestic airline sector.

Scenario 5 –Covers the period beginning 1st quarter 2009, and includes controls (imports and fuel), to test whether different effects are observed more recently, during the period of greatest consolidation. In this scenario, a decrease in domestic capacity of one percent is associated with an increase in domestic RASM of 1.28 percent, and the result is significant at the 1 percent level. Again, the adjusted R^2 in this scenario of 0.869 is much higher than in the base scenario, suggesting that capacity and RASM are more tightly correlated as we move towards a more consolidated domestic airline sector.

The results in Table 1 show that changes in the average domestic RASM can be predicted based on changes in domestic capacity, once controls for demand and fuel price are imposed and the impact of 9/11 is excluded. Fig. 3 uses the base scenario regression (Scenario 3) to plot predicted domestic RASM changes versus actual domestic RASM changes. What is striking about the plot is the degree to which predicted RASM changes closely match actual RASM changes beginning about 2006. Before that, the results vary considerably from the predicted results, and not just for the 2-year period around 9/11. The plot is graphic evidence that the link between capacity changes and average domestic RASM has been very strong over the past decade, 2006–2016. [16]

Table 2
Regression results – changes in domestic revenue regressed against changes in capacity.

	(1)	(2)	(3)	(4)	(5)
	1996-1 to 2016-3	1996-1 to 2016-3 w/ controls	1996-1 to 2016-3 Ex 2001-3 to 2003-2	2005-1 to 2016-3	2009-1 to 2016-3
Capacity	0.871	0.210	−0.523	−0.368	−0.309
Std. Err.	(0.290)***	(0.317)	(0.195)***	(0.169)**	(0.179)
Imports		0.625	0.681	0.533	0.582
		(0.137)***	(0.078)***	(0.092)***	(0.109)***
Fuel		−0.060	−0.080	0.001	−0.027
		(0.044)	(0.031)**	(0.030)	(0.036)
Constant	0.002	−0.009	0.014	0.022	0.020
F	9.00***	12.77***	50.22***	66.93***	61.22***
R^2	0.197	0.396	0.432	0.800	0.872
Observations	83	83	75	47	31

Standard errors in parenthesis (robust to heteroscedasticity).
Statistical significance at 1% (***), 5% (**), 10% (*).

5. Endogeneity – do capacity changes lead to revenue changes or do revenue changes lead to capacity changes?

Do airline capacity changes lead to revenue changes, or do anticipated revenue changes lead airlines to adjust capacity? Let's consider the evidence. As shown in section 7, for individual airlines, an increase in that airline's revenue is positively correlated with an increase in the airline's own capacity, but strongly negatively correlated with an increase in capacity by the other airlines. In practice, this means that airline executives likely expand capacity when they believe that demand is strong enough to justify the additional expense, i.e., that the additional revenue gained from a capacity expansion will exceed the additional cost. Conversely, they reduce capacity when they believe that demand is weak. Thus, at the individual airline level, the positive correlation between revenue and capacity could indicate either that airlines adjust capacity in response to anticipated revenue changes, or that capacity changes cause revenue changes, or both. For the overall airline industry, however, an increase in capacity is strongly correlated with a decrease in revenue (as well as in RASM and average airfare). The two effects - individual airline and industry - work against each other. While airline executives control the capacity of their own airline, they do not control total industry capacity. Thus, it is likely that industry capacity changes cause industry revenue changes, and are not just a reaction to them.

5.1. Dynamic adjustments

One caution regarding the application of the model is that all variables in the model are treated concurrently, which is not achievable in the real world. While current and future capacity information for all

[16] The same relationship observed between changes in capacity and RASM is also observed between changes in capacity and average domestic airfare. RASM is used in this study because it does not suffer from the effects of increasing stage length and load factors over time.

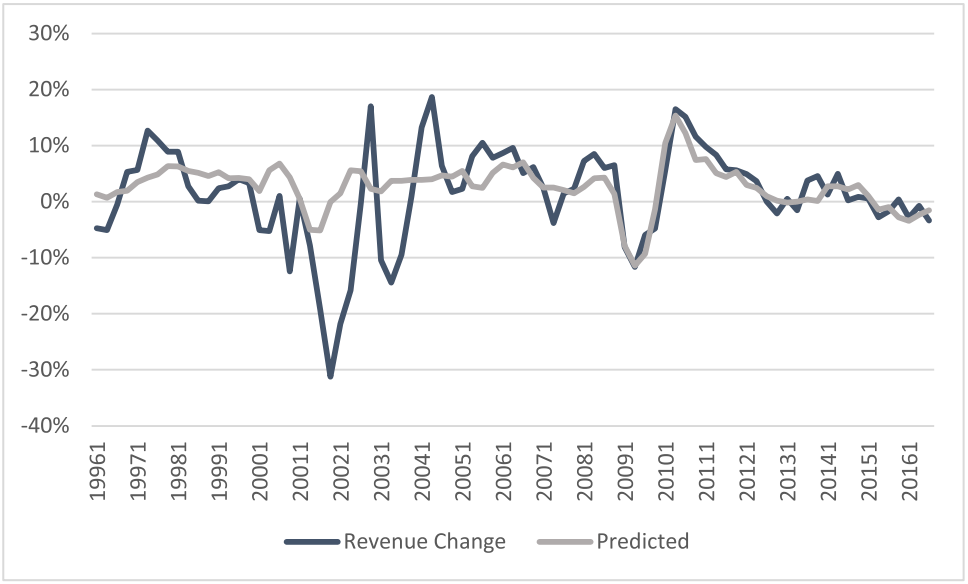


Fig. 4. Predicted annual domestic revenue change versus actual.

Table 3
Regression results for individual airlines – changes in domestic revenue regressed against changes in own capacity and other capacity.

	(1)	(2)	(3)	(4)
	American 2003-3 to 2015-2	Delta Ex 9/11	Southwest To 2011 ex 9/11	United Ex 9/11
Own Cap.	1.057 (0.322)***	0.310 (0.139)**	0.404 (0.140)***	0.482 (0.219)**
Other Cap.	−1.253 (0.307)***	−0.774 (0.339)**	−0.617 (0.218)***	−0.500 (0.123)***
Imports	0.430 (0.127)***	0.787 (0.106)***	0.679 (0.082)***	0.801 (0.096)***
Fuel	−0.014 (0.045)	−0.060 (0.030)*	−0.103 (0.032)**	−0.072 (0.030)**
Constant	0.027	0.007	0.046	0.005
F	18.64***	27.96***	33.53***	44.92***
R^2	0.602	0.449	0.542	0.719
Observations	48	75	56	75

Standard errors in parenthesis (robust to heteroscedasticity).
Statistical significance at 1% (***), 5% (**), 10% (*).

domestic airlines is readily available,[17] economic demand data is not available until after the fact. Thus, for an airline to adjust capacity, say, for the 2nd quarter based on underlying economic demand, the airline must predict what 2nd quarter imports (or the value of a similar economic indicator) will be. In addition, the airline must make this prediction by the beginning of the 1st quarter, since it takes about one quarter to implement the capacity adjustment. This is because it takes time to adjust crew schedules, planned maintenance activities, etc. and because passenger buy tickets in advance. Therefore, because the availability of economic data lags while capacity change decisions need to be made in advance, airlines will sometimes make capacity changes based on predicted economic conditions that turn out to be wrong.

When that happens – for example, revenue turns out to be weaker than expected because the economy turned out to be weaker than forecasted – airlines can respond dynamically by cutting capacity. But the same prediction and implementation time issues will apply to the adjustment process. The airline must predict the economic indicator value and allow time to implement the capacity cuts. And, importantly, reducing capacity will be of limited benefit to the airline unless the other airlines also take similar actions to reduce capacity.

6. Changes in industry capacity determine changes in industry revenue

The results show that changes in airline industry domestic revenue can be predicted based on changes in domestic capacity, once controls for demand and fuel price are imposed. The price elasticity of demand for the domestic market in the aggregate is relatively inelastic. A decrease in capacity increases the average domestic airfare sufficiently to increase domestic revenue.

[17] Airlines regularly provide public guidance regarding their expected capacity growth over the next year. And, capacity projections can also be calculated simply by analyzing flight schedules, which are generally available for the period 11 months in the future ostensibly so that travelers can buy tickets that far in advance.

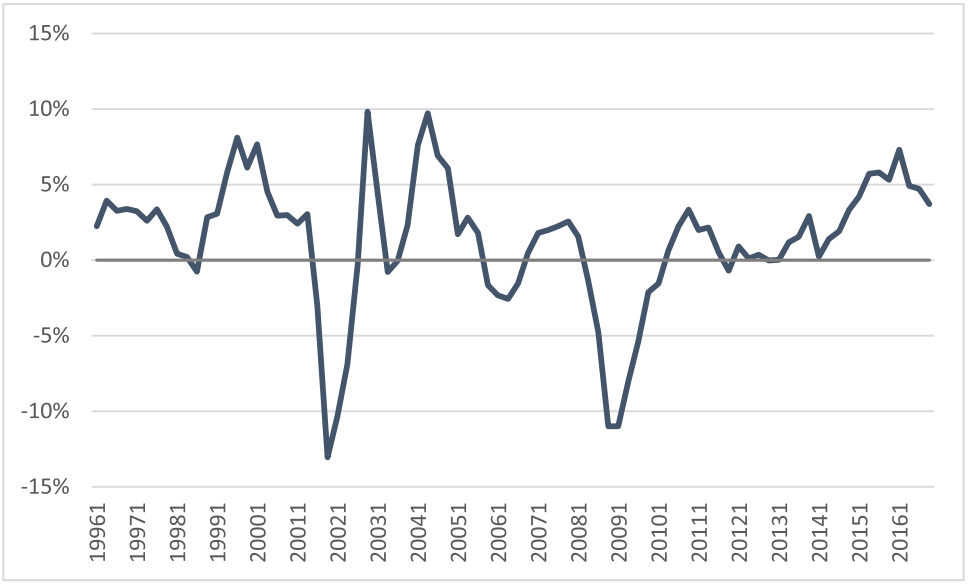


Fig. 5. Capacity change over the same quarter prior year.

Note that a wide range of elasticities applies to commercial aviation, depending on the level of aggregation and type of travel. Air travel demand at the national level – the focus of this study – is relatively inelastic compared to the individual route or market level. If airfares increase on a single route, air travelers can often substitute travel on another route. If airfares increase on all U.S. routes, air travelers can only substitute non-air travel alternatives. Similarly, air travel demand by business travelers is relatively inelastic compared with leisure travelers, because they have more limited alternatives.[18]

As in Section 4, five scenarios were modeled, with the results shown in Table 2. Before demand and fuel cost controls are added, and 9/11 effects excluded, the regression results show that a decrease in domestic capacity is correlated with a *decrease* in airline industry domestic revenue. Once these controls are added, however, the effect is reversed in that a decrease in domestic capacity is correlated with an *increase* in airline industry domestic revenue.

In Scenario 3, which includes controls, and excludes 9/11 effects, a one percent decrease in ASMs compared with the same quarter the prior year is associated with a 0.52 percent increase in airline industry domestic revenue, and the result is significant at the 1 percent level. The effect of increasing imports is to increase industry revenue, as expected.

Scenarios 4 and 5 test the effects of capacity changes on industry revenue during and after periods when the most substantial mergers occurred. The regression coefficients are lower than in the base scenario, suggesting a slightly smaller impact of capacity cuts on increasing industry revenue in the more recent years, but the explanatory power of the regression equation increases, with strong R^2 values of 0.786 and 0.858 for Scenarios 4 and 5, respectively.

Fig. 4 plots predicted domestic revenue changes using the base scenario regression versus actual revenue changes. Beginning about 2008, predicted revenue changes closely match actual revenue changes. Prior results vary considerably from what was predicted, especially for the three years following 9/11. The plot is graphic evidence that, over the period 2008–2016, the link between airline capacity changes and industry domestic revenue has been very strong.

7. Changes in individual carrier capacity and rest-of-industry capacity determine changes in individual carrier revenue

An increase in the capacity of a single airline is correlated with an increase in that airline's revenue, but an increase in capacity for the rest of the industry has an offsetting effect. These results are consistent with the basic theory that industry revenue is determined by industry capacity changes, not by individual airline capacity changes. If all airlines limit capacity, then all will obtain the revenue benefit of limited supply. If all airlines but one limit capacity and the one airline expands, that airline will still obtain most of the revenue benefit of limited industry supply.

Table 3 shows regression results for the four largest U.S. airlines.[19] For all four airlines, the impact of rest-of-the-industry capacity change on the individual airline's domestic revenue is stronger (and in the opposite direction) than the impact of the individual airline's capacity change. For example, for American (Scenario 1), a one percent increase in its own domestic capacity is associated with a 1.06 percent *increase* in American's domestic revenue, but a one percent increase in domestic capacity by the rest of the industry is associated with a 1.25 percent *decrease* in American's domestic revenue. Similarly, for the other three airlines, an increase in the airline's own domestic capacity has less effect in increasing revenue for the airline than the offsetting effect of the same increase in capacity by the rest of the industry.

8. Average capacity growth and variance among airlines has declined post-consolidation

From 2010 through 2014, domestic capacity growth did not exceed 3.3 percent during any period, an unusually long stretch of low and stable capacity growth. In 2015, however, capacity grew by over 5 percent, raising the question of whether the prior five years represented a trend or not. Domestic capacity growth for 2016 was slightly lower, after peaking in the 1st quarter. See Fig. 5. Keep in mind that these results do not control for changes in the strength of the economy or fuel price, as do the base regressions. The limited data is suggestive that the level and variance of annual capacity increases has diminished, but it is

[18] See Smyth and Pearce (2008, 18–19) for explanation of different commercial aviation price elasticities.

[19] Each of the four surviving airlines merged at least once with another airline between 1996 and 2016. In the cases of American and Southwest, the period studied was limited to avoid merger transition data issues.

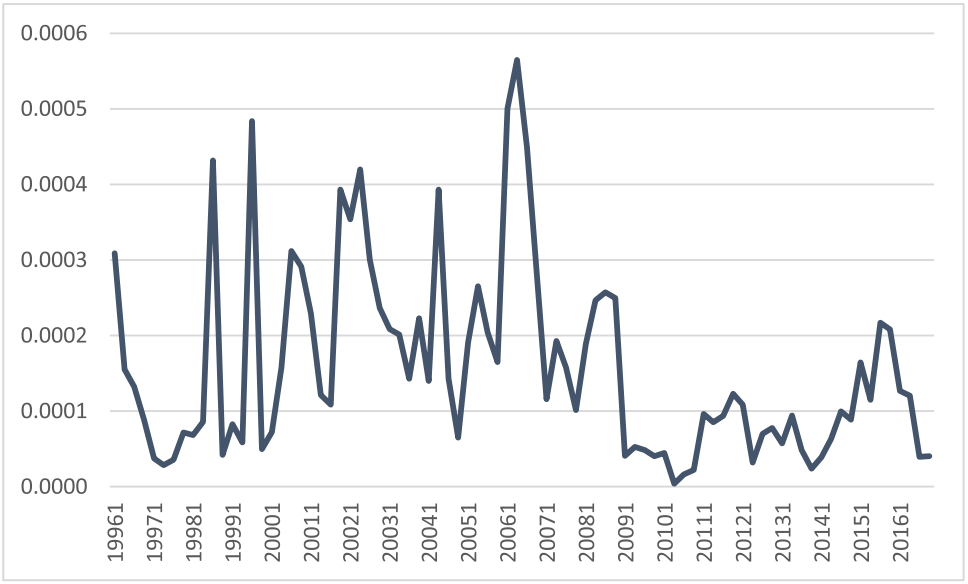


Fig. 6. Weighted variance in domestic capacity growth among seven largest airlines each quarter, 1996–2016.[20]

Table 4
Regression results – changes in domestic revenue regressed against changes in capacity.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	1996-1 to 2016-3 Ex 2001-3 to 2003-2			2005-1 to 2016-3			2009-1 to 2016-3		
Capacity			−0.325 (0.271)			−0.233 (0.178)			0.006 (0.245)
GDP	1.078 (0.382)***	0.874 (0.339)**	1.333 (0.462)***	1.724 (0.471)***	1.028 (0.346)***	1.461 (0.381)***	2.196 (0.342)***	1.338 (0.277)***	1.327 (0.645)**
Fuel		0.057 (0.028)**	0.056 (0.027)**		0.136 (0.014)***	0.123 (0.014)***		0.162 (0.023)***	0.162 (0.024)***
Constant	0.001	0.002	−0.004	0.004	0.013	0.004	0.013	0.010	0.010
F	7.98***	5.53***	6.38***	13.42***	69.56***	43.33***	41.37***	37.83***	29.82***
R^2	0.106	0.166	0.184	0.280	0.652	0.660	0.418	0.741	0.741
Obs.	75	75	75	47	47	47	31	31	31

Standard errors in parenthesis (robust to heteroscedasticity).
Statistical significance at 1% (***), 5% (**), 10% (*).

too early to draw definitive conclusions.

The results of Fig. 6, which shows the weighted variance in capacity growth among the largest airlines on a quarterly basis from 1996 to 2016, are an important indicator of the collective airline focus on capacity discipline. Although individual airlines continue to add capacity at different rates, the disparity in these rates is less than before industry consolidation. As with capacity growth, the period of low variance that, in this case, began in 2009 was interrupted in 2015. Prior to that, the variance spikes occurred following 9/11 as Southwest continued to expand while most airlines cut capacity; during the Delta and Northwest bankruptcies as those airlines reduced capacity; and during the fuel spike of 2008 as some airlines cut capacity and others continued to grow.

9. GDP growth rate as focal point for capacity growth

Many airline executives and industry analysts believe that airline revenue is maximized when airline capacity increases at approximately the same rate as GDP. Although industry vernacular does not indicate whether GDP growth is to be in real or nominal terms, logic suggests that it should be real since our estimate of revenue change is in real terms. This section examines the use of GDP growth as the focal point for capacity growth among industry insiders.

Based on analysis of the 1996–2016 data, there are better predictors of domestic revenue growth than GDP growth, such as change in imports or change in the unemployment rate.[21] GDP growth, however, does predict domestic revenue growth and may serve as a readily understandable focal point for a general airline industry audience. When GDP growth is used as the economic demand variable, the separate effect of fuel cost increases is also positive although much weaker than GDP. The effect of capacity increases on domestic revenue growth is negative for two of the three periods tested, but not statistically significant.

Table 4 suggests that when capacity and fuel prices are held constant, industry revenue has grown at 1.33-to-1.46 times the rate of real GDP growth during the three periods examined. Increasing total domestic capacity by no more than the GDP growth rate may help airlines maintain or slightly increase RASM over time.

[20] Four quarterly data points omitted for American during 2001 because of insufficient American/TWA data.

[21] When GDP growth is included in the regression along with changes in imports, the GDP growth variable is no longer statistically significant.

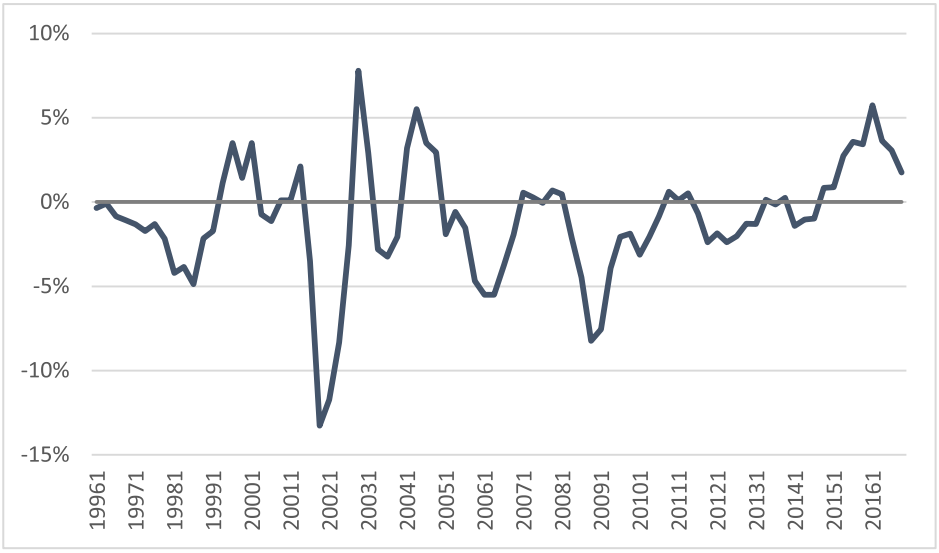


Fig. 7. Change in domestic capacity minus change in real GDP, 1st quarter 1996 to 4th quarter 2016.

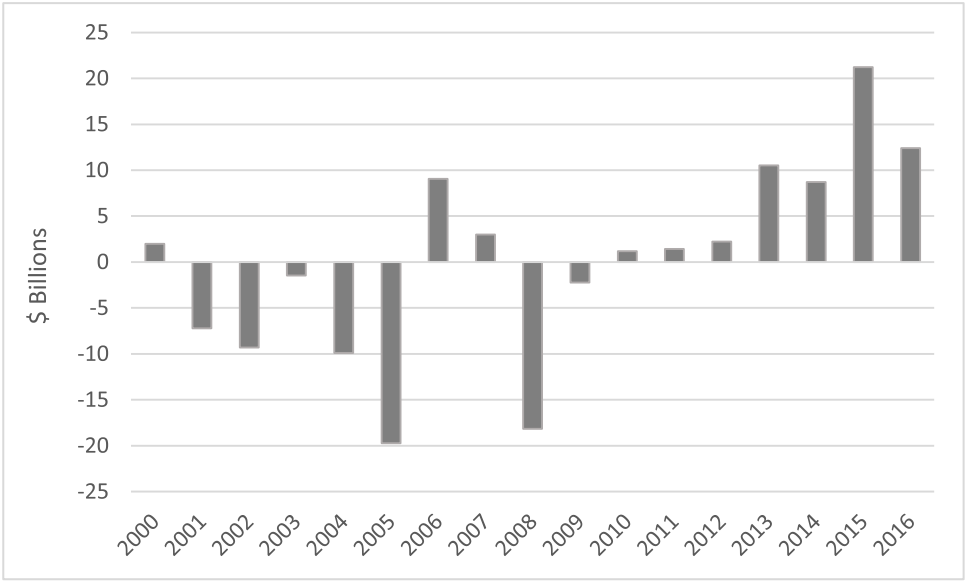


Fig. 8. U.S. airline net profits from domestic operations 2000–2016.
Source: U.S. BTS net profits from domestic operations

So, have the airlines been following the “rule of thumb” that capacity should not grow more than GDP? From 2010 to the end of 2014, capacity growth minus real GDP growth was about zero or negative, as shown in Fig. 7, and thus consistent with the rule of thumb. These changes were the lowest and most stable for any time over the past 20 years. More recently, however, capacity has been growing faster than GDP, “stoking fears that the capacity discipline integral to the industry's turnaround is evaporating” Rich (2015).

As shown in Fig. 8, the result of airline efforts to better match capacity with demand has been higher profitability. Looking forward, it seems unlikely that the four large U.S. airlines will take the risk of substantially reducing revenue or RASM by aggressively expanding capacity. However, it remains to be seen whether the four will retain the same degree of “capacity discipline” that they exercised during the 2010–2014 period.

10. Conclusion

This study shows that after controlling for the underlying level of economic demand and the price of fuel: (1) decreases in total domestic airline capacity are strongly correlated with increases in average domestic RASM; and (2) decreases in total domestic airline capacity are strongly correlated with increases in total domestic airline revenue. Airline industry focus on using the GDP growth rate as the maximum amount of capacity growth may help airlines maintain or slightly increase RASM over time. And airline efforts to better match capacity with demand have resulted in higher profitability. The data show that, between 2010 and 2014, the year-over-year domestic capacity increase and variance were lower than in the past. Also, while individual airlines continue to add capacity at different rates, the variation between airlines is much less than before industry consolidation.

These results are consistent with the theory that airline industry revenue is determined by industry capacity changes, not by individual airline capacity changes. By collectively limiting capacity, all airlines obtain the revenue benefit of limited industry supply.

These results raise several questions for further study. Why has the consolidated industry been more successful at limiting capacity growth? Is limited capacity growth a natural consequence of consolidation and, if so, is it likely to be a permanent feature of the U.S. airline industry? What factors other than industry concentration may be important in fostering “capacity discipline”?

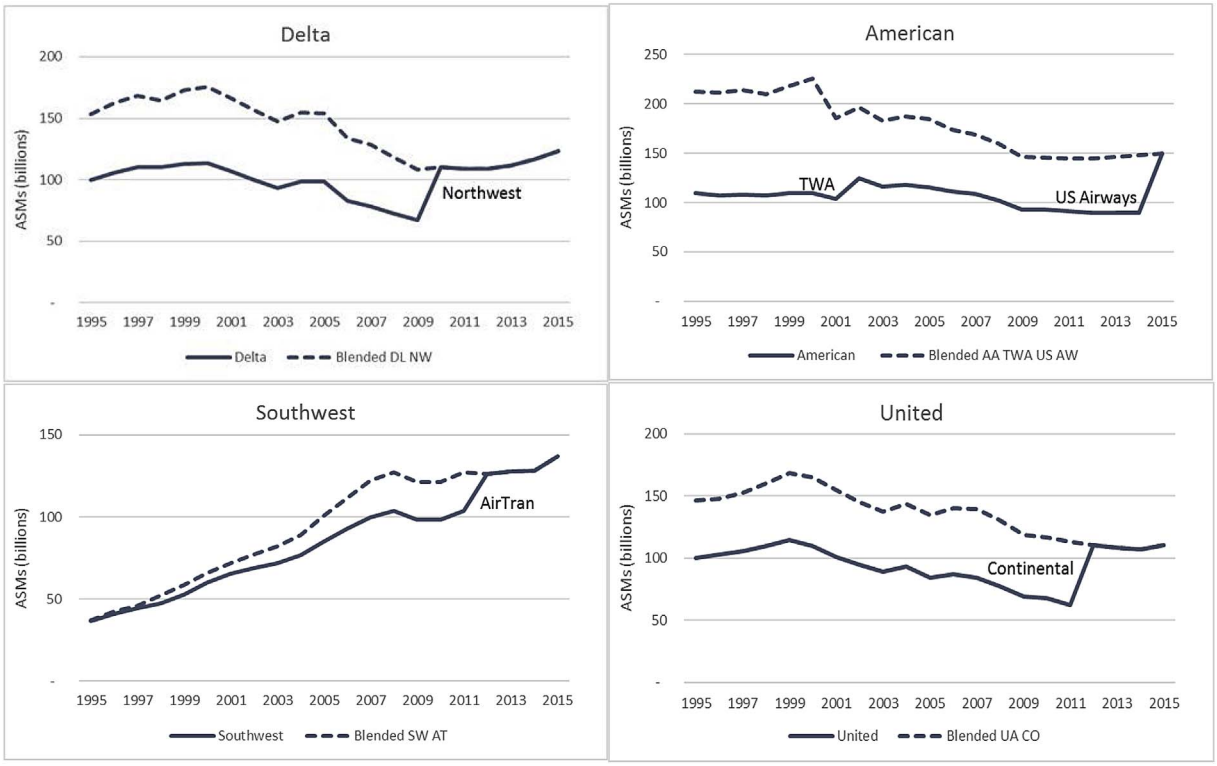
Appendix A1

Airline mergers since 2000 and capacity added by merger to four largest airlines.

Merger	Date Closed	Resulting Airline
American/TWA	4/9/2001	American Airlines
US Airways/America West	9/27/2005	US Airways
Delta/Northwest	12/31/2009	Delta Air Lines
United/Continental	10/1/2010	United Airlines
Southwest/AirTran	5/12/2011	Southwest
US Airways/American	12/9/2013	American Airlines

Source: http://airlines.org/data/u-s-airline-mergers-and-acquisitions/.

Domestic capacity showing years when mergers increased capacity for American, Delta, Southwest, United (ASMs billions).



Source: MIT Airline Data Project compilation from US DOT Form 41 via BTS, schedule T2.

Appendix A2

Data was collected from the following sources:

1. Airline domestic capacity (ASMs), departures, seats, and enplanements, from Diio commercial database, a compilation from U.S. Department of Transportation (DOT) statistics.
2. Revenue, from Diio commercial database 2000-3rd qtr. 2016, compiled from DOT statistics that are based on a 10% sample of U.S. tickets. For 1995–1999, revenue compiled directly form DOT raw data.
3. Standard measures of economic demand, including nominal and chained GDP, household income, personal income, the unemployment rate, exports, imports, from various U.S. agencies.
4. Average fuel price per gallon paid each quarter by U.S. airlines for domestic service, from US Bureau of Transportation Statistics. Before 2000, U.S. DOT data is only available on an annual basis, and therefore that data was adjusted based on other quarterly fuel price data.

The regression results were checked for collinearity and normal distribution of residuals. Collinearity was not observed. Residuals were normally distributed. Robust standard errors are used to control for heteroscedasticity.

Conflicts of interest

None.

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